

Presence of predatory lacewing (*Neuroptera: Chrysopidae, Hemerobiidae*) on Mediterranean crops

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Abstract. The presence of predatory lacewings associated with aphid pest of orchard and fruit tree crops from the Mediterranean Southern Region (SE Spain) is presented. A total of 5 lacewing species were recovered preying on 13 aphid species from 9 Mediterranean crops. The identified aphid predators were *Chrysopa formosa* BRAUER, 1850, *Chrysopa pallens* (RAMBUR, 1838), *Chrysoperla carnea* (STEPHENS, 1836), *Mallada flavifrons* (BRAUER, 1850) and *Hemerobius* spp. The most abundant species were *C. pallens* and *C. formosa*, both preying on *Hyalopterus pruni* colonies but *C. pallens* prefers the aphids present on *Prunus armeniaca* while *C. formosa* on *Prunus dulcis* and *Prunus domestica*. The Neuroptera / aphid relationship of all captured *Hemerobiidae* and *Chrysopidae* species was examined. Feeding preferences and factors that could affect the biology of this aphidophagous group in Mediterranean agroecosystems are also discussed.

Key-words: *Neuroptera*, lacewings, biological control, aphid pests, Mediterranean crops, Spain.

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I. INTRODUCTION

The study of *Neuroptera* as biological control agents against aphids, has traditionally been ignored in favour of other species of insects that are more abundant and specific. This phenomenon is due to the fact that their predatory action is greatly influenced by the ecological conditions characteristic of each habitat rather than by a particular *Neuroptera*-prey relationship (CANARD & DUELLI 1984). This is why it is essential to consider the factors which directly influence habitat selection and the biology of each species, when using these predators as biological control agents.

The *Hemerobiidae* (brown lacewings) and *Chrysopidae* (green lacewings) larvae are generally highly polyphagous, feeding on several types of minuscule phytophagous arthropods (NEW 1986). Nevertheless, adult of green lacewing feeds solely on pollen and honeydew, whereas the brown-lacewing is omnivorous (STELZL 1992). In spite of their wide trophic spectrum, both taxa have been used in several pest control programs, in both green-houses (KOWALSKA 1976) and free-crops

plague prevention (i.e.: BARTLETT 1978, GARLAND 1978). The use of these predators is particularly advantageous when compared with other aphidophagous insects. This has to do with their prey-capturing efficiency (SUNDBY 1966) and high resistance to insecticides of their preimaginal stages (DOUTT & HAGEN 1950).

On the other hand, it must be remembered that many failures of biological control programs are due to the generalization of results obtained with lacewing species from temperate zones (NEW 1988). Another fact to consider, would be the presence of groups of species with different ecologies (HENRY 1983). Unfortunately there is a scarcity of data concerning the main aphidophagous groups autochthonous to the southern zone of the Mediterranean Region and dealing especially with their ecological adaptations (ie.: GONZÁLEZ-FUNES & MICHELENA 1978, HODEK & OKUDA 1993, MARCOS-GARCÍA & ROJO 1994, ROJO & MARCOS-GARCÍA 1997). In particular, there are few monographic studies of the *Neuroptera* / aphid relationship (KILLINGTON 1936) on the world basis. This is especially true when it comes to the Iberian Peninsula (NÚÑEZ-PÉREZ et al. 1992).

The aim of this study was to analyse for the first time the presence of the aphidophagous lacewing in a variety of orchard and fruit tree crops from the Mediterranean Southern Region (SE Spain). The *Neuroptera* / aphid relationship of captured *Hemerobiidae* and *Chrysopidae* was examined. Furthermore, the relative abundance of each species, feeding preferences and factors that could affect the biology of this aphidophagous group in Mediterranean agroecosystems are also discussed.

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II. MATERIALS AND METHODS

The study area was the Alicante province located in the SE of the Iberian Peninsula. During two years (1992-1993) the principal crops affected by aphid pests were sampled, to obtain the maximum possible information about the biology of their most abundant natural predators within this type of agroecosystem.

Samples of aphid colonies were harvested and transferred to rearing boxes with their corresponding host plant from each crop to permit the development of natural enemies. Occasionally, the adults of *Neuroptera* present in the crop fields were also collected.

The rearing boxes were then taken to the laboratory and stored in the climatic chamber for 3-4 days in controlled conditions of humidity, temperature and photoperiod (21°C; 80% R.H.; 14:10). Once the storage time was over, each larva or pupa of *Neuroptera* was isolated in a corresponding Petri dish where it was fed until the appearance of the last larval stage, or the emergence of the adult.

The DIAZ-ARANDA (1992) and DIAZ-ARANDA & MONSERRAT (1995) identification keys were employed to identify the *Chrysopidae* larval stages. The larvae of *Hemerobiidae* have been identified at genus level using the keys established by VEENSTRA et al. (1990). This identification procedure was used because no other characteristics are available for identification of Iberian brown-lacewings.

III. RESULTS

A. Orchard crops

In the surveyed area, the aphids caused economic loss to various orchard crops (GONZÁLEZ-FUNES & MICHELENA 1989). However, we only found *Chrysopidae* larvae present in the aphid colonies that attacked artichoke crops (*Cynara scolymus* L.). Throughout the sampling period, we identified four species of aphids feeding on this crop: *Brachycaudus cardui* (LINNAEUS, 1758), *Dysaphis lappae cynarae* (THEOBALD, 1915), *Capitophorus elaeagni* (DEL GUERCIO, 1894) and *Aphis fabae* SCOPOLI, 1763. We detected in this crop, the presence of lacewings larvae feeding on all above mentioned aphid species, with the exception of *D. lappae*. Nevertheless, it is very likely that this aphid is also attacked since *D. lappae* colonies were frequently found mixed with *A. fabae* and *B. cardui* colonies.

The *Chrysopidae* larvae collected from artichoke aphid pests belonged to *Chrysopa formosa* BRAUER, 1850 and *Chrysopa pallens* (RAMBUR, 1838). The former was collected from *A. fabae* and *B. cardui* colonies during the spring, when the damage is most intensive. In the case of *C. pallens*, the larvae were captured as they fed on the colonies of *D. elaeagni* during the autumn.

B. Stone fruit trees

The stone fruit trees most damaged by aphid pests in the study area were the almond tree (*Prunus dulcis* (MILLER)), the apricot tree (*Prunus armeniaca* L.), the plum tree (*Prunus domestica* L.), the peach tree (*Prunus persica* (L.)) and the cherry tree (*Prunus avium* L.).

As regards the presence of aphidophagous lacewings we can state that the majority of captures were made on colonies of the mealy plum aphid (*Hyalopterus pruni* (GREGOFFROY, 1762)), in all the sampled stone fruit trees except for the cherry trees, where they were located exclusively on the *Myzus cerasi* (FABRICIUS, 1775). The presence of *Chrysopidae* larvae preying on *Brachycaudus helichrysi* (KALTENBACH, 1843) and *Brachycaudus amygdalinus* (SCHOUTEDEN, 1905) were detected in lower proportions in the crops of plum trees and almond trees respectively. On occasion, clusters of mixed colonies representing both species were observed on the former host-plant. Finally, we wish to emphasize the presence of larvae on *Myzus persicae* (SULZER, 1776) which, in spite of their extraordinary polyphagous capacity (HILL 1987), only cause damage on the peach tree crops in the studied area.

In total, larvae and adults of four aphidophagous lacewing species were identified in the sampled stone fruit trees. We collected several larvae of brown lacewings (*Hemerobius* sp.), feeding on mixed colonies of *B. amygdalinus* and *H. pruni*. The larvae of *Chrysopa pallens* and *Chrysopa formosa* were relatively abundant in the colonies of *H. pruni* in all the fruit trees that this aphid frequented. However, there was only one occasion when we detected the larvae of *C. pallens* with other aphid species (*M. cerasi*), while *C. formosa* was regularly captured on both aphids and on colonies of *B. helichrysi* in *P. domestica*. Finally, we were able to document the abundance of larvae and adults of *Chrysoperla carnea* (STEPHENS, 1836) feeding on *M. cerasi* in cherry trees and to a smaller extent on *M. persicae* in peach trees. This green lacewing was also collected from colonies of *H. pruni* in apricot trees and with *B. amygdalinus* in clusters of mixed colonies with the mealy plum aphid in almond trees, but less frequently.

C. Citrus trees

The three predominating citrus tree crops in the study area are the following: orange trees (*Citrus sinensis* (L.)), lemon trees (*Citrus limon* (L.)) and yangerine trees (*Citrus deliciosa* TEN.). All of these trees are damaged by several aphid species (HERMOSO DE MENDOZA et al. 1986), although in the studied zone we only detected the *Chrysopidae* larvae on the *Aphis spiraeicola* PATCH, 1914 and *Aphis gossypii* GLOVER, 1877, colonies, respectively. For the sake of clarity we have considered the three types of sampled citrus trees as global sampled citrus trees, since the same species of aphids were present in all of them. Furthermore, it is very common to use them as an interspecific graft pattern due to their mutual compatibility. In spite of the fact that we observed the presence of aphids throughout the spring, partially in summer and in October, their greater abundance was in May and June. It coincided with the period when the presence of aphidophagous lacewing larvae was detected.

The greatest damage was caused to the tangerine trees and in second place to the orange trees. On both crops we have collected larvae and adults of *C. formosa* and *C. pallens* feeding with equal intensity on *A. spiraeicola* and *A. gossypii* or on mixed colonies of both plagues.

D. Fruit seed trees

We have collected lacewing larvae mostly on two crops: the pear tree (*Pyrus communis* L.) and the pomegranate tree (*Punica granatum* L.).

On the pear tree crops, the most abundant sampled aphid species was *Dysaphis pyri* (BOYER DE FONSCOLMBE, 1841), which was causing considerable damage to twigs and leaves of the tree. This highly destructive activity was fundamentally observed during May. No larvae representing the *Chrysopidae* family were collected over the colonies of *D. pyri*. However, the presence of brown lacewing larvae (*Hemerobius* spp.), was documented. As a rule, the presence of the lacewings on this crop was scarce.

The pomegranate crops in the study area are very important crops from an economical point of view. In fact, approximately 96% of the the total Spanish pomegranate production comes from this geographical zone. Furthermore, aphids constitute the most menacing plague that affects this crop (TOLEDO et al. 1991). The damage is caused mainly by two aphid species: *Aphis gossypii* and *Aphis punicae* (PASSERINI, 1836), with the period of relative assault most pronounced between March and June, but the maximum degree of damage is caused between April and May. Both aphids usually form mixed colonies, *A. punicae* being the most abundant species. On these colonies, we captured larvae of four lacewing species: *C. formosa*, *C. pallens*, *C. carnea* and *Mallada flavifrons* (BRAUER, 1850). The most abundant species was *C. formosa*, and the scarcest was *M. flavifrons*, the latter collected on an ornamental pomegranate tree.

IV. DISCUSSION

As can be deduced from the results concerning the study area, the presence of aphidophagous lacewings is predominant on the colonies of aphids that damage fruit trees (Table I). According to NEW (1984) the majority of lacewing species present in the agrosystems are generally arboreus. However, the presence of these predators in orchard crops and other herbaceous plants has been documented in other areas of the Iberian Peninsula (NÚÑEZ-PÉREZ et al. 1992), although always in lower percentage than on the fruit trees.

Table I

Relationship: Lacewing / Crop / Aphid

	<i>Chrysopa formosa</i>	<i>Chrysopa pallens</i>	<i>Chrysoperla carnea</i>	<i>Mallada flavifrons</i>	<i>Hemerobius</i> spp.	N
Vegetables						
Artichoke	<i>A. fabae</i> <i>B. cardui</i>	<i>C. elaeagni</i>	—	—	—	4
Stone trees						
Almond	<i>H. pruni</i>	<i>H. pruni</i>	<i>H. pruni</i> <i>B. amygdalinus</i>	—	<i>H. pruni</i> <i>B. amygdalinus</i>	30
Apricot	<i>H. pruni</i>	<i>H. pruni</i>	<i>H. pruni</i>	—	—	36
Cherry	<i>M. cerasi</i>	<i>M. cerasi</i>	<i>M. cerasi</i>	—	—	13
Peach	<i>H. pruni</i>	<i>H. pruni</i>	<i>M. persicae</i>	—	—	8
Plum	<i>H. pruni</i> <i>B. helichrysi</i>	—	—	—	—	10
Citrics	<i>A. gossypii</i> <i>A. spiraeicola</i>	<i>A. gossypii</i> <i>A. spiraeicola</i>	—	—	—	4
Other fruit trees						
Pear	—	—	—	—	<i>D. pyri</i>	1
Pomegranate	<i>A. gossypii</i> <i>A. punicae</i>	<i>A. gossypii</i> <i>A. punicae</i>	<i>A. punicae</i>	<i>A. punicae</i>	—	24
N	71	39	15	1	4	130

Nevertheless, we believe that in some cases, despite their high degree of insecticidal resistance as compared with other aphid predators (BIGLER 1984), the scarcity of lacewings can be influenced by excessive use of insecticides. In fact, the massive employment of chemical agents in this study area may justify the absence of captures in some crops highly susceptible to aphid assaults, such as the tomato (*Lycopersicon esculentum* MILLER). This may also account for the low number of larvae detected on pear trees even fewer on citrus trees.

As far as the relative abundance of different aphidophagous lacewings over the studied crops is concerned (Fig.1), we were able to establish two groups: infrequent species (*Hemerobius* spp., *M. flavifrons*) and relatively frequent species (*C. carnea*, *C. pallens* and *C. formosa*).

The *Hemerobius* spp. larvae possibly belong to *Hemerobius stigma* STEPHENS, 1836, as this species is the only species of *Hemerobius* captured on *Pinus halepensis* M. of the Iberian Peninsula (MONSERRAT & MARIN 1996). Together with *Hemerobius nitidulus* FABRICIUS, 1777 these were

the only ones cited in the studied area and neighbouring provinces (MONSERRAT, 1984, 1985; MARIN & MONSERRAT 1991, 1995; MARIN 1994). *H. stigma* is present in the Holarctic area but it exhibits a strict relation with coniferous forests (MONSERRAT 1986). During this study we captured some examples preying on aphids of the pear tree and the almond tree. Nevertheless, in both cases, the crops were located in the vicinity of *P. halepensis* forests.

The habitat preferences of the rest of the lacewings sampled are fundamentally conditioned by the presence of *Quercus rotundifolia* LAM. In the Iberian Mediterranean forests, as they are considered highly euriotic species (MONSERRAT & MARIN 1994). In spite of *M. flavifrons* and *C. carnea*, being extremely frequent species in a wide variety of habitats and present in a wide range of geographic areas, their abundance in the sampled crop areas has been less pronounced in relation to the rest of chrysopids (Fig. 1). More ecological studies on the presence of aphidophagous lacewings in agroecosystems are necessary, but from the preference of the first species for cooler temperatures and median altitudes as well as the diversity of prey of the second (PRINCIPI & CANARD 1984), we can partially justify these results. Nevertheless, both species exhibit an affinity for Eurosiberian habitats, very scarce in the study area.

The most abundant species were *C. pallens* and *C. formosa* (Fig. 1). Both exhibit a clear relation with diverse agroecosystems, especially the former which prefers low vegetation (ASPOCK et al. 1980). Both species are widely distributed in Palearctic Region, even though they are more abundant in Mediterranean area. This is especially true in the case of *C. pallens* (MONSERRAT & MARIN 1994).

In spite of the fact that the investigated species are polyphagous, when the numbers of captures from the principal sampled aphid pests were compared, clear asymmetries could be seen (Fig. 2). Thus, a significantly much greater number of *C. formosa* and *C. pallens* larvae were obtained on the colonies of *Hyalopterus pruni* ($Z > Z_{\alpha/2}$), while the *C. carnea* larvae displayed preference for colonies of *Aphis punicae* and *Myzus cerasi*. These preferences as related to crop fields can be ascribed to the distinct and specific ecological requirements of each species.

As has already been mentioned, *C. carnea* prefers temperate zones, in fact, it was the most frequent lacewing species of the north Iberian crops (NÚÑEZ-PÉREZ et al. 1992). Thus, in the sampled

[Figure 1]

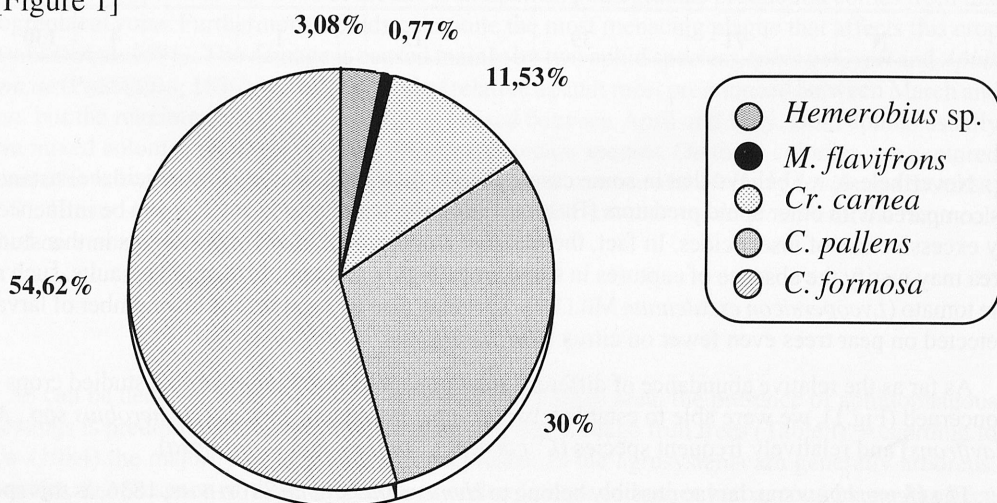


Fig. 1. Lacewing abundance in the studied area.

zone, the cherry fruit trees (with *M. cerasi*) are concentrated in its northern third where the mean temperature is lower than in the south, and the precipitation is maximum. The presence on a typical Mediterranean crop such as pomegranate, is undoubtedly due to the fact that these fruit trees are damaged by the aphids earliest. In relation to other lacewings, *C. carnea* is usually the first species to colonize cultivation fields because of its ability to hibernate in the adult stage, which distinguishes it from the others (NEW 1988).

An initial approximation of the trophic spectrum of *C. pallens* and *C. formosa* in the studied areas indicates that both species live on the same aphid colonies, but the latter always predominates (Fig. 2). However, comparing these data with the presence of both species on the variety of sampled crops (Fig. 3), differences between the two are patent. Hence, considering their presence on *Hyalopteris pruni* colonies, it can be seen that *C. pallens*, associated with the most thermic areas of Mediterranean area (MONSERRAT & MARIN 1994), fundamentally selects the colonies present on *Prunus armeniaca* and to a lesser extent on *Prunus dulcis* ($Z > Z_{\alpha/2}$). On the contrary, the *C. formosa* larvae were captured in an inverse proportion on both crops ($Z_{\alpha/2}$) and also on *Prunus domestica* (Fig. 3). This differential choice of crops can be explained by the seasonal succession of *H. pruni* in the studied zone. Thus, in harmony with the arboreal development, the mealy plum aphid initiates its assault on the almond tree crops in the midst of spring, switching onto plum trees at the end of this season and finally settles on the apricot trees by mid summer. According to these data, the maximum predatory activity of *C. formosa* would be prior to that of *C. pallens*, the former initiating its activity in mid summer. This hypothesis also coincides with the significantly pronounced presence of *C. formosa* on the colonies of *A. punicae* in pomegranate. On the other hand, and in spite of the fact that *C. pallens* appears to be characteristic of tall vegetation crops (NÚÑEZ-PÉREZ et al. 1992), we were

[Figure 2]

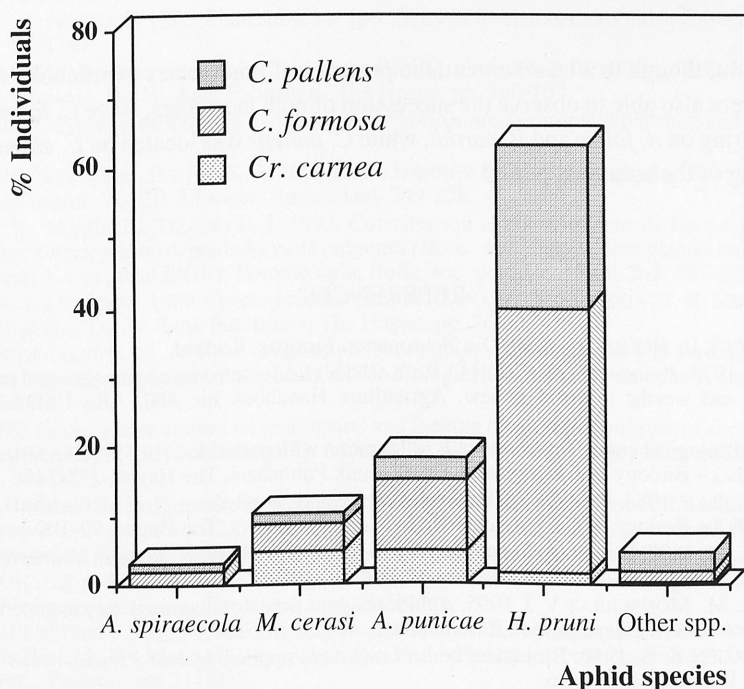


Fig. 2. Trophic spectrum of Chrysopidae species in the main sampled aphid pests.

[Figure 3]

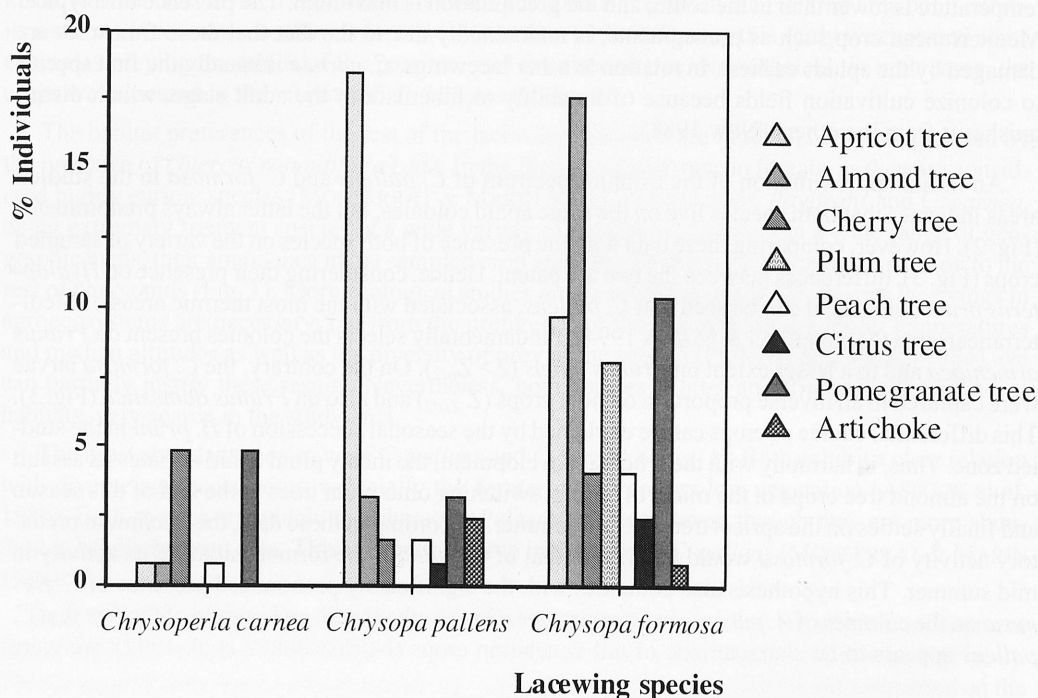


Fig. 3. Percentage of lacewing captures in the sampled crops.

able to document, though to a lesser extent, the presence of this species in artichoke fields. In this last case, we were also able to observe the succession of both lacewings, since *C. formosa* was collected in the spring on *A. fabae* and *B. cardui*, while *C. pallens* was located on *C. elaeagni* colonies at the beginning of the autumnal period.

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